

# Impact of Metropolitanization on Covid-19 Cases in India using Entropy Weights Based Topsis Approach

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## ABSTRACT

The global pandemic COVID-19 which was started early this year spreading rapidly in developed countries as well as developing countries of the world. The noticeable fact is that most of the metropolitan cities of the world are severely affected by Corona pandemic and topped in their respective country among the COVID cases. The impact of the metropolitan city on COVID-19 cases, example can be cited around every corner of the world, From Wuhan to New York, Mumbai to Sao Paulo and Moscow to Madrid the Metropolitan cities of the world's come out as deep-rooted hotspots of novel coronavirus pandemic. *Mumbai, Delhi, Chennai, and Kolkata* are the leading metropolis in India also leading in COVID-19 cases; it can be explained by their connectivity to the rest of the world by the people and products. Therefore this article aims to summarise the impact of six metropolitan cities on the total COVID-19 cases of their states and try to find out which city have best suited in the concept of the Metropolitanization of COVID-19 cases. Entropy-based TOPSIS methods are applied to compare the dataset of six metropolitan cities of India, and try to find out which city best fitted in the concept of metropolitanization of COVID-19 cases. Seven factors are chosen to analyze the impact of metropolitan cities on COVID-19 cases such as city population, percentage of slum population, number of COVID cases, airport traffic movement, relative humidity, and temperature. Entropy methods applied to weights the criterion for finding which criteria have maximum influence on COVID-19 cases. After that on the basis of Entropy weights, the TOPSIS method has been used to evaluate the dataset of six cities to track down the relative position of cities on the concentration of COVID-19 cases. After comparing the alternatives in TOPSIS method (i.e those six cities), Delhi came in the first position, followed by Mumbai (2<sup>nd</sup>), Chennai (3<sup>rd</sup>), Kolkata (4<sup>th</sup>), Ahmedabad (5<sup>th</sup>), Hyderabad (6<sup>th</sup>) based on the concentration of COVID-19 cases in the metropolitan cities.

**KEYWORDS:** COVID-19, Metropolitan city, Metropolitanization, Entropy Method, TOPSIS approach

## INTRODUCTION

COVID-19 virus started its journey from China (Wuhan city) traveling across the world and reached almost every city. This virus is amongst the deadliest virus known to men and continued its havoc impact on the health care system of most of the countries. The noticeable fact is that most of the metropolitan cities of the world like *New York* (3.98 lakhs) and *California* (2.24 lakhs) in the USA, *São Paulo* (2.81 lakhs) in Brazil, *Moscow* (2.21 lakhs) in Russia, *Madrid* (0.67 lakhs)\* in *Spain* are severely affected by Corona pandemic and topped in their respective country in COVID cases. In 2003 a similar kind of virus name SARS (severe acute respiratory syndrome) hit global cities of the world like Beijing, Hong Kong, Toronto, Hanoi, and Singapore[1]. The COVID-19 pandemic can be regarded as a negative impact of globalization, it influences many biological, social, and environmental factors on which pathogen's to survive and cause human disease[2]. The cities of developing countries particularly susceptible to infectious disease, because of their weak health

infrastructure, limited medical and financial resources not sufficient to cope with up with such a pandemic.

Across the globe, the vibrant nature of cities bringing the people together with an intense degree of social, economic, and political interaction which became a hallmark of metropolitan cities. Cities such as *new work, London, Dubai, Singapur, Rome* where people came from different countries are lived, studied, and work together and ultimately led to high social interaction and it always increased chances of emergence of infectious diseases. If infectious disease broke out one city, severely affected other cities also through the global air network. COVID-19 pandemic first notices at a market in Wuhan, one of the largest Chinese city and a major transportation node with national and international connections, through air transportation and trade linkage it reached other parts of the globe[3].

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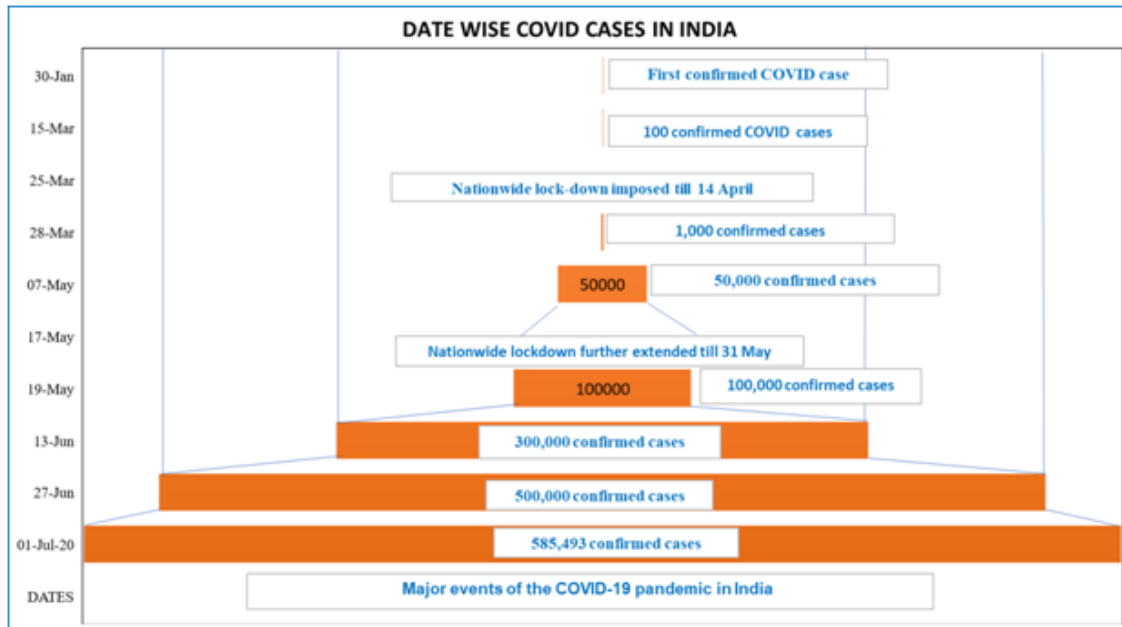


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**Metropolitanization of COVID-19 cases in India:** India As a part of the globalized world the COVID-19 pandemic came to air Route. The first case of COVID-19 in India was reported on 30 January 2020 in Thrissur city, Kerala with a traveled history from Wuhan, China. Despite 68 days strict lockdown implemented in India from 24<sup>th</sup> March (2020) India Rank forth\* in terms of COVID-Cases. After 1<sup>st</sup> June, Relaxation was introduced under the name of Unlock-1. In the month of June 3.76 lakhs, corona cases are reported, resulting in a drastic 66 % increase in corona cases.[4] Around all reported COVID-19 cases in India, nearly fifty percent of cases belong to the Six metropolitan cities - Mumbai, Delhi, Chennai, Kolkata, Ahmedabad, and Hyderabad. Major cities like Delhi and Mumbai are severely affected, hospitals are struggling to accommodate even critically ill patients. In India, around 24 % of the people of India lived in slum areas [5] which increases the chances of community transmission.



**Figure 1: Major events during COVID-19 pandemic situation**

Asia's largest slum Dharavi, (Mumbai) which is, the total number of COVID-19 positive cases is 2301[6]. Slum dwellers are less aware of the pandemic situation and shared a single room with 8-10 people with fewer precautions to protect themselves. A high amount of migratory workers specially labourer worked in cities and lived congested with minimum spaces for social distancing. Under these circumstances, cities are always prone to infectious diseases. COVID-19 cases are mainly clustered in metropolitan cities like Hyderabad (75 %), Kolkata (62%), Chennai (65%), Ahmedabad (65 %), of all registered cases of Telangana, West Bengal, Tamil Nadu, and Gujarat. The ongoing coronavirus disease is an example of the close relationships between urbanization, slum population, movement of peoples infected areas to other areas.

\*based on data of 1st July, 2020



**Figure 2: Distribution of COVID-19 cases in India and the location of Six metropolitan town**

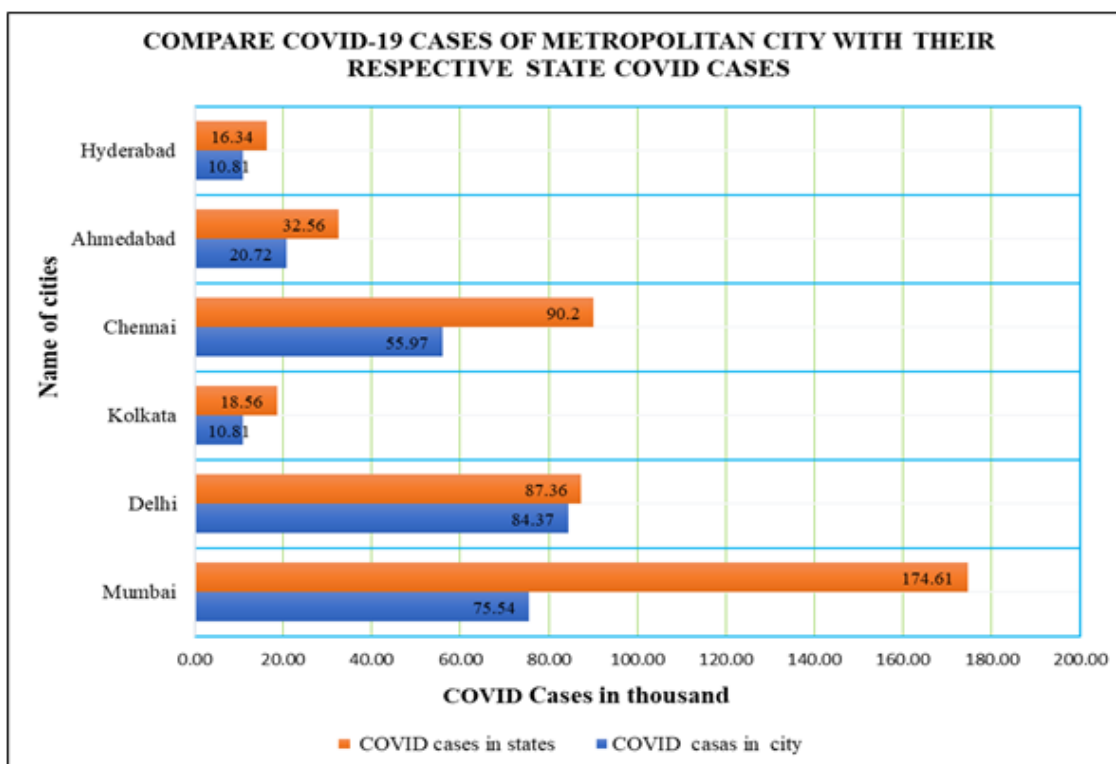


Figure 3: Comparison COVID cases of a metropolitan city with their state COVID-19 cases

#### Methods:

The reason behind the concentration of COVID-19 cases in the Metropolitan cities of India are analysis. Seven criteria initially selected to judge the impact of COVID-19 cases on six metropolitan cities. Entropy-based weights methods are applied to weights of criteria to find out those criteria which benefitted the virus to concentrate on cities. After criteria weights are determined, TOPSIS methods are used to compare the dataset of six cities and find out which city has the best-suited in Metroplitanization of COVID Concept. It can be said that among the six cities where maximum concentration COVID-19 cases based on suitable associated conditions .among the criteria Low temperature taken as beneficial criteria for COVID-19 cases which increases virus viability and high relative humidity benefits the virus to grow in TOPSIS METHOD. The present study based on secondary data sources, criteria that are used for evaluation of Metropolitan impact on COVID-19 are discussed with their sources.

**Total COVID-19 cases in Metropolitan cities:** here six metropolitan cities are taken from six states which have more than 50 lakhs population and also severely affected by COVID-19 Virus. COVID-19 data[7]are collected from publicly available web portal ([covid19india.org](http://covid19india.org))and data are validated from the Ministry of Health and Family Welfare website.

**Airport passenger flow:** Corona virus disease first spreading rapidly between the cities through global air travel networks. Airport passenger flow data are taken as criteria from 1<sup>st</sup> April 2019- 31<sup>st</sup> March 2020. (<https://www.aai.aero/>)[8].

**Slum population:** Poorly maintained health and hygienic facilities and lacks of space for maintaining social distancing increasing the chances of contagion and community transmission. The date on the percentage of slum population are collated from the Ministry of housing and urban poverty Alleviation websites. (<http://mohua.gov.in>.)[9]

**City population:** The urban population of India concentrated in a few large metropolitan cities due to high migration from rural and small-town to these cities in search of jobs. Data on the urban agglomeration of metropolitan collected from the census of India sites.(<https://censusindia.gov.in>,2011).[10]

**Percentage of COVID-19 cases in Cities to the total cases of State:** percentage of COVID cases are compared to total COVID-19 cases of states for measuring Metropolitan influence on COVID-19 cases. ([covid19india.org](http://covid19india.org))

**Temperature:** Higher temperature are linked with lower COVID-19 infection, temperature more than 38°C virus lost its viability quickly, on a temperature around 22–25°C this virus can remain for 5 days and at a temperature of 4 °C can be persisted for as long as 28 days. [11 & 12]

**Relative humidity:** A combination of low temperature and low humidity environment can increase the stability of corona virus like air-conditioned environments. On the other hand, high temperatures and higher relative humidity virus lost its viability quickly. Those cities are badly affected by the COVID-19 virus where average temperatures around 5°C-11°C and low relative humidity.[13]Data on average temperature and relative humidity for the month of June retrieved from the Indian metrological department website([mausam.imd.gov.in](http://mausam.imd.gov.in))[14].

**Entropy Weights Based TOPSIS METHODS:**

The entropy method is developed by Shannon (1948) [15]. Entropy weights methods recently gained its popularity due to its advantage of free from human interference on the criteria weights. This method less influenced by human biasedness enhancing the objectivity of evaluation results. [16, 17 & 18].

**Weight Determination based on Entropy Methods:**

**Step-1: Scoring:** with the help of expert guidance identifying the evaluation criteria and Establish a decision matrix for the ranking  $X = (x_{ij})_{m \times n}$ , where  $m$  denote the number of alternatives. each alternative is evaluated with respect to  $n$  criteria.

$$D = \begin{bmatrix} x_{11} & x_{1j} & x_{1n} \\ \vdots & \vdots & \vdots \\ x_{i1} & x_{ij} & x_{in} \\ \vdots & \vdots & \vdots \\ x_{m1} & x_{mj} & x_{mn} \end{bmatrix} = \begin{bmatrix} D_1 & (x_1^1) \\ \vdots & \vdots \\ D_j & (x_j^j) \\ \vdots & \vdots \\ D_m & (x_m^m) \end{bmatrix} \dots \dots \dots \text{equation 1}$$

**Step-2: Normalize decision matrix**, here the criteria values are standardized using the following equation

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^m x_{ij}} \dots \dots \dots \text{equation 2}$$

**Step-3, Compute the entropy value  $e_j$  "ej" is calculated as in**

$$e_j = -h \sum_{i=1}^m r_{ij} \ln r_{ij}, j = 1, 2, \dots, n \dots \dots \dots \text{equation 3}$$

Where  $h = \frac{1}{\ln(n)}$

**step-4, Calculating the entropy weight "wj" of index j: "wj" is calculated as in**

$$w_j = \frac{1 - e_j}{\sum_{j=1}^n (1 - e_j)}, j = 1, 2, \dots, n \dots \dots \dots \text{equation 4}$$

**The TOPSIS method**

The TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method was first developed in 1981 by Hwang and Yoon [19]. It is one of the popular and widely used MCDM methods to evaluates the goodness of alternatives based on the shortest distance from the ideal solution and the farthest from the negative ideal solution [20-26]

We can calculate TOPSIS with the following steps, Pazand(2012)[27]

**Step 1: Construct the decision matrix.** This matrix is the same as Entropy decision matrix given in equation .1

**Step-2: Normalisation of the decision matrix(R)** Each attribute value  $x_{ij}$  in the matrix  $X$  is normalized with a corresponding value  $X_{ij}$  The normalized value  $X_{ij}$  is calculated as:

$$\bar{X}_{ij} = \frac{X_{ij}}{\sqrt{\sum_{j=1}^n x_{ij}^2}} \dots i = 1, 2, \dots, n, j = 1, 2, \dots, n \dots \dots \dots \text{equation 5}$$

**Step 3: Calculate the weighted normalized decision matrix:** multiplying the normalized decision matrix by resulted weights which are determined in the entropy method multiplying ( $W_j$ ) in Phase Calculation. The weighted normalized value  $v_{ij}$  is

calculated as

$$v_{ij} = w_j * \bar{X}_{ij} \quad i = 1, 2, \dots, n, j = 1, 2, \dots, n \dots \dots \dots \text{equation 6}$$

**Step 5: Determination of the positive and negative ideal solutions.** Using Equations (3) and(4), the set of positive ideal solutions ( $A^+$ ) and the set of negative ideal solutions ( $A^-$ ) are calculated respectively.

$$A^+ = \left\{ \left( \max_i V_{ij} \mid j \in I' \right), \left( \min_i V_{ij} \mid j \in I'' \right) \right\} = \{V_1^+, \dots, V_j^+\} \dots \dots \dots \text{Equation 7}$$

$$A^- = \left\{ \left( \min_i V_{ij} \mid j \in I' \right), \left( \max_i V_{ij} \mid j \in I'' \right) \right\} = \{V_1^-, \dots, V_j^-\} \dots \dots \dots \text{equation 8}$$

Where,  $V_j^+ = \text{indicates the ideal best value}$



$V_j^-$  = indicates the ideal worst value

where  $I'$  is associated with the benefit criterion (the higher the better) the ascend factor, and  $I'''$  is associated with the cost criterion (the lower the better).

**Step 6: Distance scale calculated:** by Euclidean distance is the distance between each objective and ideal solution or anti-ideal solution. " $S_i^+$ " represents the distance between the objective and ideal solution "A+", and " $S_i^-$ " represents the distance between the objective and anti ideal solution "A-".

$$S_i^+ = \left[ \sum_{j=1}^n (v_{ij} - v_j^+)^2 \right]^{0.5} \dots \dots \dots \text{equation 9}$$

$$S_i^- = \left[ \sum_{j=1}^n (v_{ij} - v_j^-)^2 \right]^{0.5} \dots \dots \dots \text{equation 10}$$

**Step 7:** Calculation of the relative closeness coefficient to the ideal solutions. The relative. closeness coefficient of the ith alternative with respect to the ideal solutions is defined as

$$P_i = \frac{S_i^-}{S_i^+ + S_i^-} \dots \dots \dots \text{equation 11}$$

" $P_i$ " is in the range of 0 to 1, The larger the index value, the better the performance of the alternatives.

**Table 1: Criteria taken for Entropy Weights methods**

	A1	A2	A3	A4	A5	A6	A7
Mumbai	0.2925	0.1111	0.2581	0.2449	0.2408	0.1539	0.1911
Delhi	0.3268	0.2398	0.2286	0.1171	0.3532	0.1826	0.1563
Kolkata	0.0419	0.1514	0.1978	0.1861	0.1155	0.1581	0.1911
Chennai	0.2168	0.1582	0.1206	0.1685	0.1169	0.1731	0.1563
Ahmedabad	0.0802	0.1579	0.0884	0.1493	0.0600	0.1736	0.1538
Hyderabad	0.0419	0.1815	0.1066	0.1341	0.1136	0.1587	0.1514
$E_j$ =entropy value	0.8509	0.9852	0.9575	0.9834	0.9078	0.9989	0.9970
$D_j = 1 - E_j$	0.1491	0.0148	0.0425	0.0166	0.0922	0.0011	0.0030
wj	0.4671	0.0463	0.1332	0.0519	0.2888	0.0034	0.0093

**Table 2: Table for normalization matrix and weights results**

Name of State in which city belong	Name of Metropolitan City	COVID-19 cases in the city on 1 <sup>st</sup> July (in thousand) (A1)	Percentage of COVID cases to the total cases of State (A2)	Urban population of city ( in crore) (A3)	Slum population (%) (A4)	airports passenger traffic flow between April 2019- 31 March 2020 (A5)	Average monthly temperature (degree) for month of June,2020 (A6)	Humidity of the air (%) in month of June (A7)
Maharashtra	Mumbai	75.54	45.885	1.84	42.00	4.59	28.9	77
Delhi	Delhi	84.37	99.051	1.63	20.09	6.73	34.3	63
Kolkata	Kolkata	10.81	62.541	1.41	31.91	2.20	29.7	77
Tamil Nadu	Chennai	55.97	65.344	0.86	28.89	2.23	32.5	63
Gujrat	Ahmedabad	20.72	65.229	0.63	25.60	1.14	32.6	62
Telangana	Hyderabad	10.81	74.977	0.76	23.00	2.17	29.8	61

**Table 3: Normalize decision matrix for TOPSIS method**

	A1	A2	A3	A4	A5	A6	A7
Mumbai	0.5859	0.2650	0.5894	0.5822	0.5062	0.3762	0.4655
Delhi	0.6545	0.5721	0.5222	0.2785	0.7426	0.4465	0.3809
Kolkata	0.0838	0.3612	0.4517	0.4423	0.2429	0.3866	0.4655
Chennai	0.4341	0.3774	0.2755	0.4004	0.2457	0.4231	0.3809
Ahmedabad	0.1607	0.3768	0.2018	0.3548	0.1262	0.4244	0.3748
Hyderabad	0.0839	0.4331	0.2435	0.3188	0.2389	0.3879	0.3688

**Table 4: Weighted normalize decision matrix for TOPSIS**

Weighteds	0.4671(A1)	0.0463(A2)	0.1332(A3)	0.0519(A4)	0.2888(A5)	0.0034(A6)	0.0093(A7)
Mumbai	0.2736	0.0123	0.0785	0.0302	0.1462	0.0013	0.0043
Delhi	0.3057	0.0265	0.0696	0.0145	0.2144	0.0015	0.0035
Kolkata	0.0392	0.0167	0.0602	0.0230	0.0701	0.0013	0.0043
Chennai	0.2028	0.0175	0.0367	0.0208	0.0710	0.0014	0.0035
Ahmedabad	0.0750	0.0174	0.0269	0.0184	0.0364	0.0015	0.0035
Hyderabad	0.0392	0.0200	0.0324	0.0166	0.0690	0.0013	0.0034
$V_j^+$	0.3057	0.0265	0.0785	0.0302	0.2144	0.0013	0.0034
$V_j^-$	0.0392	0.0123	0.0269	0.0145	0.0364	0.0015	0.0043

**Table 5: calculation of Euclidean distance ( $S_i^+ + S_i^-$ ) performance score ( $P_i$ ) and Ranking of Cities**

Name of the cities	$S_i^+$	$S_i^-$	$S_i^+ + S_i^-$	$P_i = \frac{S_i^-}{S_i^+ + S_i^-}$	Rank
Mumbai	0.0767	0.2645	0.3412	0.7751	2
Delhi	0.0181	0.3236	0.3418	0.9469	1
Kolkata	0.3039	0.0483	0.3522	0.1373	4
Chennai	0.1819	0.1677	0.3496	0.4796	3
Ahmedabad	0.2962	0.0365	0.3327	0.1096	5
Hyderabad	0.3075	0.0340	0.3415	0.0996	6

### Results and Discussion:

Seven criterion are selected for measuring which city suited perfectly in the concept of metropolitanization of COVID-19 cases, Entropy methods applied for determining the weights of seven criterion on six metropolitan cities, (see table no:2 ) the results show that the *Total number of COVID-19 cases in metropolitan city (46 %) came in 1<sup>st</sup> position*, from this techniques. As this technique is free from human judgment it can be Reliable. Actually this the prime consideration for this study, if the number of COVID-19 cases are more concentrated in cities it's should be an indication of the Metropolitanization of COVID-19 cases and all other factors are dependent on it. *Airport passenger traffic flow (28 %) came 2<sup>nd</sup> in criteria ranking* because in most of countries and also in India COVID-19 virus came through air routes and spreading all through the country. *The urban population of City (13 %) came in 3<sup>rd</sup> position*, this is another important criteria because more the urban population of city , more chances of interaction among the peoples and also increases the chances of Virus spreading. *Percentage of slum population in cities (5%) came 4<sup>th</sup> position*, this is one of the important variables because maximum chances of community transmission are from slum areas where high population density, congested household, less awareness about pandemic situation worsen the situation. After calculating performance score of the cities in TOPSIS methods, the position of the cities are (see table: 4) Delhi<sup>1<sup>st</sup></sup> (0.9469), Mumbai 2<sup>nd</sup> (0.7751), Chennai 3<sup>rd</sup> (0.4796), Kolkata 4<sup>th</sup> (0.1373), Ahmedabad 5<sup>th</sup> (0.1096), Hyderabad 6<sup>th</sup> (0.0996).

Though in India 65 % population are lived in rural areas, more than 50 % of COVID-19 cases are reported from large metropolitan cities. Through the global network of air connectivity, Virus made his route to came in India in the form of droplet transmission. high population density, enclosed spaces, poor housing conditions, lack of civic awareness in urban areas provide a breeding ground for this infectious virus to spread. It was noticeable that in

India most of the COVID-19 patients are either belong to the metropolitan town or have travel history from aboard. Comparing the alternatives in the TOPSIS method (i.e those six cities), Delhi came the first position because of three reasons Delhi has 97% urban population that means there is no rural population as such so it benefits Delhi in the ranking. Another reason, Delhi is the capital of India and most of the cities of the world are directly connected through air, so Delhi has maximum airport passenger flow, which increases the chance of spreading viral infection due to high interaction from other countries. Delhi is the capital city high rate of internal migration from other states in search of a job and opportunity to increase interaction. Maharashtra is the worst affected states and Mumbai came at second position because apart from Mumbai (43%) there is another two cities in Maharashtra, Thana (22%) Pune (13%) also severely affected, if combined those three cities COVID-19 cases, 78 % cases belong to those three cities. As this study has considered only metropolitan cities (more than 50 lakhs population) that's why Mumbai came in the second position. In Mumbai city, 42 % of the population lived slum areas as previously speculated in slum areas chances of community spreading is much more due to lack of spaces for maintaining social distancing and unaffordability of buying masks or others preventive measure. Chennai came in 3<sup>rd</sup> position, it is the largest city in the whole south india and dominated influence on the Tamil Nadu economy so a high level of interaction can cause more COVID cases in this city. Kolkata, Ahmedabad, Hyderabad comes in 4<sup>th</sup>, 5<sup>th</sup> and 6<sup>th</sup> position in those cities also have a high percentage of COVID cases compare with the states total but as those cities, the number of COVID cases and other associated factors like temperature, relative humidity, airport passenger flow are less from first three cities.

### Conclusion:

Since, on 3<sup>rd</sup> July, India has recorded the biggest single-day jump in the number of COVID-19 cases With nearly 22,000

cases ([www.worldometers.info/](http://www.worldometers.info/)). The COVID-19 situation is getting worse day by day. The states of Maharashtra is the worst-hit state in India with a total case of 186,626, while Mumbai's corona virus cases jumped to 80,262 ([www.business-standard.com/](http://www.business-standard.com/)). Delhi city cross 90000 corona cases, The states of Tamil Nadu reached 98,392 cases with the city of Chennai have 62598 cases. On the basis of this data, it is perceived that how the cities are severely affected by COVID-19 pandemic cases through the higher movement of peoples causing higher transmission. The impact of the metropolitan city on COVID-19, example can be cited around every corner of the world. From Wuhan to New York, Sao Paulo to Mumbai and Moscow to Madrid the Metropolitan cities of the world's come out as deep-rooted hotspots of novel corona virus pandemic. This study only considering seven criterion for supporting our statement that metropolitan cities are the carriers of the COVID-19 virus and it traveled by the global network of air transport move from their source area to the other destination. So there is lots of scopes in this area of inquiry by considering such factors i.e. *percentage of migratory work, way of urban lifestyle, pollution level, trade relation and government policy for managing the infectious disease*. Finally, Entropy weights based TOPSIS methods are useful for this study to find out which city are the perfect example of Metropolitanization of COVID-19 cases because of its rationality of judging criteria without human interference.

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No one sought

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#### Competing interests

None Declared

#### Reference:

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